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‘This is the peer reviewed version of the following article:
Smith, P. A., Raven, M. D., Walshe, K., Fitzpatrick, R. W., &
Pate, F. D. (2017). Scientific evidence for the identification
of an Aboriginal massacre at the Sturt Creek sites on the
Kimberley frontier of north-western Australia. *Forensic
Science International*, 279, 258–267. [https://
doi.org/10.1016/j.forsciint.2017.08.018](https://doi.org/10.1016/j.forsciint.2017.08.018)

which has been published in final form at

<http://dx.doi.org/10.1016/j.forsciint.2017.08.018>

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Accepted Manuscript

Title: Scientific evidence for the identification of an Aboriginal massacre at the Sturt Creek sites on the Kimberley frontier of north-western Australia

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PII: S0379-0738(17)30317-1
DOI: <http://dx.doi.org/10.1016/j.forsciint.2017.08.018>
Reference: FSI 8961

To appear in: *FSI*

Received date: 5-1-2017
Revised date: 12-8-2017
Accepted date: 14-8-2017

Please cite this article as: Pamela A.Smith, Mark D.Raven, Keryn Walshe, Robert W.Fitzpatrick, F.Donald Pate, Scientific evidence for the identification of an Aboriginal massacre at the Sturt Creek sites on the Kimberley frontier of north-western Australia, Forensic Science International <http://dx.doi.org/10.1016/j.forsciint.2017.08.018>

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Scientific evidence for the identification of an Aboriginal massacre at the Sturt Creek sites on the Kimberley frontier of north-western Australia.

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HIGHLIGHTS

- Results of a scientific investigation of a reported massacre, Kimberley, Australia.
- XRD analysis showed all bone fragments subjected to extreme temperatures to 800°C.
- Pathology concluded bone fragments as possibly human but evidence inconclusive.
- Comparison with burnt bone from hearth sites showed hearth fires were cooler.
- Archaeological signatures for similar remote Aboriginal massacre sites identified.

Abstract

Archival research into episodes of frontier violence in the Kimberley region of Western Australia indicate that the bodies of Aboriginal victims of massacres were frequently incinerated following the event. This paper presents the results of a scientific investigation of a reported massacre at Sturt Creek where burnt bone fragments were identified in two adjacent sites and documents the archaeological signatures associated with the sites. The methodology used to undertake the project brought together three systems of knowledge: the oral testimonies of the descent group originating from a sole adult survivor of the massacre; archival, historical and scientific research. An archaeological survey defined the two distinct sites containing hundreds of fragile bone fragments; a third site was found to be highly disturbed. Scientific investigations included macroscopic and

microscopic examination of selected bone fragments by an anatomical pathologist and a zooarchaeologist and X-ray diffraction analysis of sixteen bone fragments.

The anatomical pathologist and zooarchaeologist undertook macroscopic and microscopic examinations of selected bone samples to identify morphological evidence for human origin. It was concluded that three bone fragments examined may have been human, and two of the fragments may have been from the vault of a skull. It was concluded that the likelihood of them being human would be strengthened if it was found that the three samples had been subjected to high temperatures. X-ray diffraction analysis of 16 bone fragments provided this evidence. All fragments showed sharp hydroxylapatite peaks (crystallite sizes 9882nm and 597nm respectively) and all had been subjected to extreme temperatures of either 600°C for more than 80 hours, 650°C for more than 20 hours, 700°C for more than 4 hours or 800°C for more than 1 hour. XRD analyses were also done on bone samples collected from three cooking hearths at three different archaeological sites. It was found that two of the three samples had been exposed to substantially lower temperatures for a short time period. It was concluded that there was strong pathological and archaeological evidence that the bone fragments were human in origin, but that the evidence was not conclusive. This research also identified archaeological signatures for the identification of massacre sites in similar Australian environments and circumstances.

Keywords: Massacre archaeology; XRD burnt bone; Kimberley frontier; Australian Aboriginal massacres; Sturt Creek massacre

Introduction

Locating physical evidence to support the many reported massacres¹ of Aboriginal people on the Australian colonial frontier has been limited (1), (2), (3), (4). Although there are many oral histories and reports of massacres in archives and newspapers in each Australian state, the identification of physical remains continues to challenge scientists and archaeologists (5), (6) (7). At the time of commencing this study only three archaeological studies of such sites containing *in situ* human remains have been reported in Australia (8), (9), (10). In the remote desert areas of northern Western Australia, the location of this study, the difficulties inhibiting the identification of such sites include the destruction of physical evidence by burning without burial, leaving only surface scatters of highly degraded fragmented bone and taphonomic processes resulting from weathering, trampling by cattle, tropical rain, wind and shifting sand (11), (12). In addition, it was anticipated that bone preservation would be poor due to high soil pH.

Research into the reported massacre at Sturt Creek in the southeast Kimberley region of Western Australia was undertaken at the request of the descendants of those killed. The descendants are

¹ A definition of ‘massacre’: ‘A massacre is the killing of a large number of people at the same time in a violent and cruel way’ (<https://www.collinsdictionary.com/dictionary/english>). A number is not specified here, but 2 or more people killed is acceptable (Lyndal Ryan personal communication).

also the custodians and Native Title holders of the location in which the reported massacre took place. The Kimberley Land Council (KLC) had received a grant of \$24,000 from the Australian Institute of Aboriginal and Torres Strait Islander Studies to undertake this study and it was the site at Sturt Creek that the Chairman of the KLC recommended for investigation by this research team.

The aims of the investigation were to (i) document and interpret archaeological evidence, oral testimonies and historical evidence of the massacre event; (ii) contribute to archaeological and scientific research into frontier studies in Australia and (iii) identify and record historical information about the nature of frontier conflict in the Sturt Creek region.²

The aims of this paper are to present the results of an archaeological and scientific investigation of the reported massacre on Sturt Creek where burnt bone fragments had been identified in two adjacent sites and to document the archaeological signatures associated with the sites. It was not possible to undertake any other form of identification, for example DNA analysis, due to the poor preservation of the bone. The focus was, therefore, on the post mortem taphonomic agents, ie burning and environmental.

The location of the Study Area is adjacent to the old Denison Downs homestead overlooking Chuall Pool on Sturt Creek and approximately 100 km south of Halls Creek in the east Kimberley region of Western Australia, refer to figure 1.

Material and Methods

Members of the research team consulted with representatives of the descent group for approximately eighteen months prior to commencing the archaeological survey and it was agreed that the senior custodians would attend the field survey. We were made aware that the spirit of the dead person continued to reside in each bone fragment and the ethical issues were, and continue to be, complex. The following conditions were imposed on the investigators: (i) all soil samples containing fragments of bone would be returned to the descent group for reburial once the laboratory investigations had been completed (13). This was complied with in 2011 and a plaque recording the event was erected at the massacre site at the time the samples were reburied. (ii) The size of soil samples was restricted to the 120 mm x 80 mm sample bags shown to the group. (iii) The descent group would be provided with a draft of each media release and other publications. Later, following a meeting in 2014, representatives gave written approval for the authors to make the Final Report of the project available to the public.

Meetings with the representatives of the descent group were held in 2010, 2014 and 2016. This research proposal was approved by the Behavioural and Research Ethics Committee, Flinders University (reference 4067, 2008). The research proposal complied with the Guidelines for Ethical Research of AIATSIS, the funding body, and the KLC Ethics Committee.

² The extent of violence on the Australian colonial frontier has been contested, particularly over the past two decades. Known as the ‘history wars’ this debate has resulted in a growing number of published oral histories by Aboriginal people and texts by academics from both sides of the debate. For more information refer to https://en.wikipedia.org/wiki/History_wars

Our investigation into the origin of the two scatters of bone fragments identified by the descent group brought together knowledge from three culturally diverse knowledge systems and this collaboration formed a powerful methodology to address the project objectives. Aboriginal knowledge of the event and its location was provided by one adult, Riwari and one child, Clancy, the sole survivors of the massacre. Their oral histories were passed to their descendants and recorded in paintings, see figure 2 for an example, and several interviews over many years (14), Milner Sturt personal communication 1994, Speiler Sturt personal communication 2009). As stated above, the location of the massacre is well known by members of the descent group who make regular visits to the area. The descent group referred to throughout this paper are the descendants of those killed and of Riwari, the adult survivor.

The second knowledge system was the written records of the white people, primarily in this instance, the police, government departments and newspapers. Their records represent the colonial justice system of the dominant culture during the late nineteenth and early twentieth centuries. The objective of the historical research was to locate documented evidence of the massacre and to understand the relationships and tensions between the Aboriginal people and invading colonists, primarily miners and pastoralists, between the mid-1880s and 1922, the year of the Sturt Creek massacre.

The third knowledge system was the knowledge of scientists from the disciplines of archaeology, science and medicine (15). These specialists interpreted the evidence, that is, the artefacts, burnt bone fragments and site formation processes collected or documented during the archaeological survey. The archaeological field survey of an area 250 m x 200 m was undertaken by a zooarchaeologist, an archaeologist and a field assistant. This was the area identified by the descent group as the site of the reported massacre; it was surveyed over three days in October 2009. Features identified within the survey area included a stone-lined well filled with sand, an open site comprising eight small separate scatters of bone inside a yard enclosed by a dry-stone wall and referred to by the descent group as the goat yard, a second scatter of fragmented bone 70 m south-west of the well referred to as the 'women and children' site by the descent group, the footing of the Denison Downs Homestead (abandoned in 1901) and a scatter of artefacts typical of those expected adjacent to a remote nineteenth century homestead on a cattle station (16), (17), (18). This single-roomed building was abandoned in 1901 and a new homestead built approximately 5 km away and renamed Sturt Creek Station. Several hundred bone fragments were macroscopically examined *in situ* at the two scatters of bone fragments by the zooarchaeologist and soil samples containing fragments of bone < 2 mm were collected from each site (19).

X-ray diffraction analyses of bone fragments were undertaken by the CSIRO Land and Water Division, Urrbrae, South Australia, to determine the temperatures at which the bone fragments had been and the length of time they were exposed to high temperatures. Bone fragments collected at the site were also examined for anthropomorphic characteristics by an anatomical pathologist from the Institute of Medical and Veterinary Science, Adelaide, South Australia, and by a zooarchaeologist from the South Australian Museum. An organic chemist was consulted about whether hydrocarbon residues from a possible massacre event could have survived. The condition of the bone fragments was considered to be degraded for DNA testing; this decision was made following discussions with staff at the Ancient DNA Laboratory, University of Adelaide (20). Data

from each of the three knowledge systems were collated, interpreted and then considered together to identify evidence of a massacre event.

Results

Indigenous knowledge. This is a summary of the Indigenous oral testimonies (for a full account refer to (21)). According to information from the oral testimonies, those who died in the massacre were reported to have been both Jaru and Walmajarri people and today most of their descendants live in the Billiluna and Mulan Aboriginal communities (figure 1). A large number of Aboriginal people (the number was not specified) were camped near Godfrey Tank on the Canning Stock route and had been cooking a camel when they were ambushed by a police ‘punitive expedition’.

As with many oral testimonies, minor details of the event have varied over time but the main events are consistently the same. Following the murders of two white men, Joseph Condren and Tim O’Sullivan, at Billiluna Station, an unknown number of Aboriginal people were shot between wells 48 and 49, near Godfrey’s Well in the region known as Kuningarra on the Canning Stock route (figure 1). The number killed is not provided, but those not shot when the ammunition was exhausted were forced to wear neck chains and walk past to the old Denison Downs homestead. That ammunition would have been available at Sturt Creek Station provides an explanation for this movement of the prisoners. The group included men, women and children. The adults were chained to trees within a stone wall enclosure known as the goat yard where they were shot, while women and children are believed to have been shot a short distance away. Some bodies were placed in the well and burnt. One Aboriginal man, Riwarri, and his young son, Clancy, escaped. Riwarri hid Clancy inside the carcass of a dead bullock and then, breathing through a reed, moved underwater along the Sturt Creek. He was pursued by the police but escaped and later lived and worked on Sturt Creek Station and was father to several more children.

Three locations at the suspected site of the reported massacre were shown to the research team by members of the descent group. Two were open sites containing scatters of burnt bone fragments. One was identified as the ‘women and children’ site, the location where the women and children are believed to have been killed. The other open site was within a dry-stone walled enclosure known as ‘the goat yard’. A third site, a stone-lined well, features in all accounts of the massacre. The well, however, was found to have been highly disturbed in the recent past and no bone fragments were found. The site of the massacre is illustrated in figure 2.

Archival research. The murders of Joseph Condren and Tim O’Sullivan is well documented (22), (23). This event took place in September 1922 and provides an approximate date for the reported massacre on Sturt Creek. An Aboriginal man, Banjo, was the suspected killer and he and his wife were pursued by a police party led by Constable Flinders and Banjo was tracked and shot (24).

Consignment 653 – file 1922 O/83 Murders of Condren and O’Sullivan also contains records of a second police party led by Constable J.J. Cooney from the Turkey Creek Police Station had left Halls Creek two weeks after the police party led by Constable Flinders and spent between October 12 and October 31, 1922, on Walmajarri country in the Kuningarra region (25). This is both the time and place where the oral testimonies of the descents of Riwarri describe the first massacre on

the Canning Stock Route. Although the second police party was away for almost three weeks, the entries in the police diary of Constable Cooney are either scant or missing. He did note that his party included the brother of Tim O'Sullivan, one of the men murdered at the old Billiluna homestead. At no time did Constable Cooney's police party attempt to follow the party led by Constable Flinders or assist in the hunt for Banjo. The diary also reveals that following the return of this police party to Billiluna homestead they took a further eight days to travel to Ruby Plains homestead, a period that is unaccounted for and three-four days longer than their journey into the search area three weeks earlier. No documents reporting the massacre at either Kaningarra or Sturt Creek were identified through police reports and other archival sources.

The killing and of Aborigines was not a rare event in the East Kimberley region following the arrival of the first pastoralists and miners in the mid-1880s. Commissioner Wood, in his report on the *Royal Commission of Inquiry into Alleged Killing and burning of Bodies of Aborigines in the East Kimberley and into Police Methods when Effecting Arrests, 1927*, concluded that there was, in the East Kimberley, 'a conspiracy of silence'. In 1926 Dr Adams, a medical doctor who had worked in the Kimberley region for seventeen years, with the last ten as the medical officer based in Wyndham, provided possibly the most damning evidence to the Wood Royal Commission. He stated: 'I calculate that in the north during the last fifty years something like 10,000 natives have disappeared by devious means, not necessarily old age' (26), see also (27), (28) (29) for further information about frontier conflict in this region.

Zooarchaeology and archaeology. All artefacts associated with the 250 m x 200 m survey area were recorded. Features within this area include the homestead site, a stone-lined well and two open sites containing scatters of bone fragments and charcoal. The homestead site and associated artefacts and the well are not relevant to this paper and are not included. The hundreds of fragments of burnt bone at the two open sites, that is, the 'women and children' site and the goat yard, were examined *in situ* for diagnostic characteristics. No other cultural material, for example, hearth stones or stone tools, were identified in association with the bone scatters or identified within the survey area.

The concentrations of burnt bone at both sites varied in density and soil samples were collected and paired with soil samples collected from adjacent areas without bone. Ten soil samples were collected from the loose top soil in the goat yard and each revealed highly fragmented (<20 mm in width or length) bone embedded in burnt soil, see figure 3. Several members of the descendant group confirmed that many bullets/cartridges had been collected from within the goat yard and many were now in the homes of people living in their community.

Bone routinely dehydrates under intense heat, causing cracking which in turn results in high rates of fragmentation (30), (31). Almost all bone fragments from the two sites were calcined to white / blue, with a few to brown / black, suggesting particularly high temperatures (32), see also (33) - a summary of literature relating to burnt archaeological bone. Three samples of bone fragments were selected for specific microscopic analysis by the anatomical pathologist due to their preserving some morphology.

The scatter of bone fragments referred to by the descendants as the 'women and children' site was an open area approximately 60 m x 40 m. The ground was scattered with rubble, small pieces of hematite rock and bone fragments. The bone fragments were not randomly strewn around but

found to be highly localised. One particularly dense concentration and forming a rough circle of approximately 120 cm diameter was targeted for further investigation. A hard, compacted layer of soil beneath the loose top soil contained fragments of burnt bone and charcoal. A surface scrape running approximately 100cm east/west and 40cm north/south was scraped down to the compacted soil layer. Loose soil was carefully sieved off and the bone macroscopically viewed for diagnostic elements, colour and texture. Most fragments of burnt bone, some blackened but most calcined to white/blue were found to be the same as burnt bone fragments identified in the goat yard, see figure 4.

Macroscopically it was obvious that a high temperature fire had occurred here. High temperature fires more readily destroy bone with thinner cortical surfaces and greater cancellous internal structure, such as cranial or some pelvic elements. Conversely bone with thicker cortical structure and limited internal cancellous structure, such as long bones demonstrate better survival rates in high temperature fires. This results in scatters of mostly long bone fragments that are highly calcined and very few, if any, fragments of non-long bone shafts (34), (35). The abundance of small fragments of calcined and mostly cortical bone at this site are typical of harder skeletal material fracturing and splitting during exposure to high temperatures and softer, porous bone dissolving. Soil scrapes containing bone fragments were collected and provided samples for microscopic analysis by the anatomical pathologist.

The third site identified by the descendants, the well, was excavated by them. The sandy soil was described as highly disturbed 'fill' with no soil profile, for example, two halves of a single bovine rib were recorded at different levels within the well. Members of the group of descendants reported that the well was unlike their previous visit several years earlier when the stone bottom was visible. No fragments of bone, burnt or otherwise, were found at the bottom of the well.

The homestead ruin and associated artefacts were separate from the areas containing bone fragments, the nearest being the 'women and children' site which was on the other side of the station track (formerly a section of the Canning Stock Route) and approximately 100 m to the south-east. The goat yard was over 150 m to the east of the ruin. None of the artefacts associated with the homestead ruin could be identified as being associated with a massacre event. Almost all artefacts were typical of those associated with late nineteenth century/early twentieth century remote pastoral stations, including a few bullets and cartridges (36), (37). The absence of ammunition in the survey area was not considered critical to the investigation as members of the descendent group reported that informal collecting had been taking place for many years, particularly in the goat yard.

Anatomical Pathology. Five bone fragments selected from the soil samples were examined at the Institute of Medical and Veterinary Science (IMVS), Adelaide. Each of the five specimens, GY1, GY2, GY3, WC1 and WC2 were blind-coded to minimize bias before submitting them for examination and no specific information was provided regarding their origin or the circumstances at the site where the specimens were obtained.

A slow-speed saw was used to cut out a 3mm thick slab from the central region of each specimen. This provided two parallel flat surfaces from the interior of each specimen which was then

embedded in a block of epoxy resin. This was then placed in a special bone microtome to shave 5µm-thick sections of the resin block containing portions of bone or other tissue constituents of the specimen. Each 5 µm section was mounted on a glass slide using a transparent adhesive and covered by a thin glass coverslip. The methodology aimed to provide thin samples from each specimen for microscopic examination at high magnifications. The aim of microscopic examination was to confirm that each sample was bone and to identify if anthropomorphic characteristics were present, thus confirming the bone fragments were of human origin. Each specimen underwent thorough exterior examination by stereoscopic microscope followed by radiography using a high-resolution x-ray machine.

Despite having embedded the specimens in resin to prevent their fragmentation and to preserve the micro-anatomical relationships of the tissue components, every attempt to prepare sections suitable for microscopy ended in failure. Each specimen was composed wholly of dust and was completely lacking in fibrous and other connective tissues which normally maintains the micro-anatomical integrity which characterizes each type of body tissue, including bone. This inability to prepare thin sections of old spongy cancellous bone from archeological sites for microscopy is not unknown. Regrettably, the restriction of the examination of samples to naked-eye or low-power microscopic study alone imposed substantial limitations on the amount of useful information despite the availability of radiographs.

Specimen WC1. Under low-powered microscopy a part of the sample showed an extremely thin outer rim of dense bone but the sample was mainly composed of plate-like cancellous bone having very few rod-like trabeculae. This predominance of plate-like structures in humans is observed in the rim of the pelvis, the bones of the wrist, and in the hind-foot and mid-foot. Long bones of sheep and goats also reveal comparatively dense bone. It could not be confirmed if this bone was human or non-human.

Specimen WC2. The sample is a 5 mm-thick curved structure having a relatively smooth convex surface with a small number of circumferentially oriented crack-like crevasses up to about 2 mm in depth. The inner surface was irregular and devoid of convincing trabecular structures. The cut surface showed a few very small channels which could be Haversian systems but was largely and uniformly amorphous. While the specimen could be a portion of compact cortical bone from the shaft of a limb bone having a calculated diameter of about 20 mm it was not possible to exclude the sample as originating from a non-animal source, such as piece of hard or fossilized wood. The latter possibility was reinforced by the X-ray, which showed a uniformly radio-opaque internal structure as well as the lightness in weight when compared with the other specimens³.

Specimen GY1. Part of an expanded end of bone with a small outer portion of dense shaft-like outer cortex tapering into an expanded portion composed of rod-like and plate-like trabecular cancellous bone. The expanded portion became very dense as it terminated by merging with the

³ X ray diffraction analysis found the dark, wood-like fragments ~20mm long to be low crystalline hydroxylapatite, meaning the bone was subjected to relatively low temperatures, probably below 550°C. This is high enough to carbonize the organic matter but not high enough to alter the crystallite size.

convexly curved bone end-plate which, in life, would normally be covered by a layer of articular cartilage in contact with a similar opposing cartilaginous surface within a joint. In humans, bone having these features can be seen in the metacarpal bones of the hand and the metatarsal bones of the feet, and, depending on stature, the digits of both extremities.

Specimens GY2 and GY3. These specimens were considered together as they had similar appearances. The cut surfaces showed a ‘sandwich’ type structure with a homogeneous and featureless central black layer about 5 mm in width enclosed between uniformly grey layers about 1 mm in thickness. The inner concave grey layer of GY2 contained a few channels which could be vascular but were not convincing as Haversian systems. There was no evidence of cancellous bone being present on the concave surface. The sandwich-type structure occurs in the skull of humans, the sternum and, to some degree, in the ribs. The presence of white material on both surfaces of sample GY2 indicates the sample was possibly exposed to intense heat, resulting in calcination of the surfaces. The presence of white material on samples GY1 and WC2 may also indicate exposure to intense heat.

The pathologist drew the following conclusions from these five samples:

- Specimens WC1 and GY1 were identified as definitely bone.
- The density of plate-type cancellous bone in Specimen WC1 increases the possibility of the sample being human in origin, although there remains a small possibility that it is non-human in origin.
- Specimen WC2 lacks strong evidence that it originates from the bony skeleton, it is possible that it is not animal.
- Specimens GY2 and GY3 are similar in structure and while they have meagre features supporting a skeletal origin it is possible that they are fragments of bone from the vault of the skull. This latter possibility would be strengthened if there was evidence that they had been exposed to extreme heat as partial calcination may have occurred.
- The uniformly dense appearances of the X-rays of specimens WC2, GY2 and GY3 could indicate that the specimens are either not bone or bone in which there has been an intrusion of radio-dense soil or other material into the marrow spaces.

Despite repeated attempts it proved to be impossible to prepare any of the samples for microscopic study. However, the fact that the tissues transformed to dust were a strong indication of the absence from the bone of proteinaceous material (e.g. collagen) which normally binds the calcific (hard) components to form bone tissue. The possibility of applying DNA technology to the five specimens was raised during the microscopic examination, but such techniques depend upon the identification of human or animal DNA in plasma constituents extracted from the bone. These tests cannot, however, be applied to bones that no longer have extractable proteins, such as bone which has been burnt or at high temperatures, such as those described below (38), (39), (40).

XRD Analysis. Sixteen bone fragments were examined at the X-ray Diffraction Laboratory, CSIRO Land and Water, Adelaide. The samples were photographed using a Wild Leitz stereomicroscope and a Lumenera 10MP colour digital camera. Small sub-samples were removed and ground in an agate mortar and pestle and the fine powders sprinkled onto Si low background holders for XRD analysis. XRD patterns were recorded with a PANalytical X'Pert Pro Multi-purpose Diffractometer using iron filtered Co Ka radiation, variable divergence slit and fast

X'Celerator Si strip detector. The diffraction patterns were recorded in steps of 0.0167° 2-theta with total counting time of 30 minutes, and logged to data files for analysis using HighScore Plus from PANalytical and in-house XPLOT. Estimates of crystallite size were performed with TOPAS from Bruker AXS on the XRD data using a crystal structure determination from bone hydroxylapatite. The crystallite size determined by XRD is limited by the inherent resolution of the instrument, which is estimated to approximately 700nm.

Heating experiments on samples of dried animal bone (sheep) were also performed at temperatures of 200, 400, 500, 550, 600, 650, 700, 800 and 1100°C over time intervals of 1, 2, 3, 4, 8, 16, 32, 64, 120 hours. The bone heated to 550° was also heated over longer intervals up to 300 hours. Crystallite size was determined at each temperature and duration and compared against the crystallite sizes determined for the bone fragments.

Results of XRD analysis: The photographs, XRD patterns and estimations of crystallite size and approximate temperature and duration were recorded for each of the 16 fragments. Two examples are illustrated below in figures 5 and 6 and in table 1, and in figures 7 and 8 and in table 2.

Crystallite size of hydroxylapatite was determined by measuring the width at half height of hydroxylapatite XRD patterns at several temperatures and heating durations for bone (41). The crystallinity of the hydroxylapatite phase (determined by the sharpness of the hydroxylapatite XRD peaks) in all the bone fragment samples indicates that the hydroxylapatite is well crystalline, which is typical of relatively high temperature heating (i.e. greater than 650°C) as shown in figure 9.

All the light brown to white coloured fragments appear to have been heated to high temperatures ($>800^\circ\text{C}$) for short periods of time or lower temperatures ($600\text{--}700^\circ\text{C}$) for many days (Tables 1 and 2). All fragments that are dark or black in colour have low crystallite sizes. An observation made whilst performing the heating tests was that the colour change from dark to light usually occurred about the same time as the crystallite size increased. It is likely the reason the crystallite size takes such a long period of time at lower temperatures is the access of oxygen to oxidize the organic matter between the bone crystallites. The black fragments seem to indicate that during heating these bone fragments are under reducing conditions and the organic matter has converted to carbon instead of CO_2 . The carbon has, therefore, inhibited the bone fragments from re-crystallizing.

This evidence, that of all 16 bone fragments were exposed to extreme heat supports the macroscopic examination. The researchers are confident that all bone fragments analysed from Sturt Creek had been subjected to temperatures of either 600°C for more than 80 hours, 650°C for more than 20 hours, 700°C for more than 4 hours or 800°C for more than 1 hour. These results are based on measurements of clean animal bone (i.e. no adhering flesh) at each of the temperatures over many hours (figure 9). These high temperatures and the prolonged period of burning are considerably greater than the hearth fire of a hunter/gatherer. Bone fragments from hearth fires from three archaeological sites, Allen's Cave, Butchers Quarry and Black Swamp, were also tested by XRD analysis. The samples from the goat yard and 'women and children' site showed sharp hydroxylapatite peaks (crystallite sizes 9882nm and 597nm respectively), which is consistent with

heating to $>650^{\circ}\text{C}$. Two of the three hearth site samples (Allen's Cave and Butchers Quarry) had broad hydroxylapatite peaks (crystallite sizes 54nm and 33nm respectively) and consistent with heating to temperatures lower than 650°C . The third hearth site sample (Black Swamp) had sharp hydroxylapatite peaks (crystallite size 580nm), consistent with heating to $>650^{\circ}\text{C}$. the crystallite strain showed a similar trend to the crystallite size (M. Raven, personal communication).

Only highly fragmented and fragile burnt bone was present at the goat yard and 'women and children' sites. All bone fragments were on the surface and there was no other archaeological evidence or debris of a meal (whether Aboriginal or European), in addition, no hearth material, cooking stones or other cultural materials were present. No evidence of hydrocarbons, an indication of a fire-accelerant, was found in association with the bone fragments due to the age of the bone and desert conditions. Use of a fire accelerant was, however, considered unlikely given the remote location and circumstances described in the oral testimonies.

Discussion

Anecdotal evidence exists for over thirty massacres in the Kimberley Region of Western Australia during the period of frontier conflict (approximately mid-1880s to 1930s). The reported sites on Sturt Creek were selected for investigation because the location was well known, members of the descent group had requested that the study be undertaken, they participated in the archaeological survey and had given their approval for the outcomes of the study to be published. The following oral testimony was given by the descendants of two witnesses to these massacres, an adult and a child, and describe the killing of Aboriginal people following the murder of Condren and O'Sullivan at Billiluna homestead in 1922. The first reported massacre was at Kaningarra on the Canning Stock Route. Whilst they were supposedly searching for Banjo (suspected of killing Condren and O'Sullivan), the police party led by Constable J.J.Cooney failed to fully account for their precise whereabouts for a period of over three weeks. It was established from Constable Cooney's own police report that his police party had travelled west from old Billiluna (Kilangkarra) Station and were in the same area where the Kaningarra massacre allegedly took place and at the same time as the massacre. According to the oral testimonies the survivors of this first massacre were chained by the neck and then taken to old Denison Downs homestead on Sturt Creek, the site of the second reported massacre and this investigation.

Although no documented evidence supporting a massacre on Sturt Creek was found, the location of the massacre site was well known to the descent group and they directed the archaeologists to the three sites. Surface scatters of burnt bone and charcoal fragments were identified in two of the three locations within the area surveyed. Soil samples containing bone fragments $< 20\text{ mm}$ were collected with the approval and assistance of the descent group; the recovered bone fragments were later examined in a laboratory by an anatomical pathologist, zooarchaeologist and by scientists.

The bone fragments selected for microscopic examination by the anatomical pathologist concluded that samples WC1, GY2 and GY3 provided strong evidence that the bone fragments were of human origin and that GY2 and GY3 were similar in structure and possibly fragments of bone from the vault of a skull. Although the report did not provide conclusive evidence that diagnostic anthropomorphic characteristics were present, it was concluded that the possibility of human origin would be strengthened if there was evidence that they had been exposed to extreme heat resulting in partial calcination.

The X-ray diffraction analysis provided this evidence and demonstrated that all sixteen bone fragments from the 'women and children' site and the goat yard had been subjected to extreme temperatures of either 600°C for more than 80 hours, 650°C for more than 20 hours, 700°C for more than 4 hours or 800°C for more than 1 hour. These results indicate that large quantities of fuel (cut timber) were used to maintain fires at a high temperature over a sustained period (over 140 hours in some samples). Experiments conducted to establish the temperature range of a typical hearth fire showed that the temperatures identified by X-ray diffraction analysis were considerably higher than a traditional Aboriginal hearth fire in two of the three samples examined.

Small fragments of burnt charcoal were found in association with the scatters of burnt bone fragments and two fragments of burnt rock were also recorded. No similar fragments of burnt charcoal were identified in soil samples collected adjacent to the bone scatters and all charcoal fragments were associated with the bone fragments. It was concluded wood was used to fuel an event and that the charcoal did not originate from a background burning event. It was concluded from the analysis of taphonomic processes, that is, regular inundation from tropical rainfalls, day time temperatures of up to 45°C, aeolian processes and possible trampling by stock animals, for almost a century that bone and charcoal deposits had been eroded and degraded.

Conclusions

We believe our multidisciplinary method combining data from three knowledge systems, that is, the oral testimonies and art of the descent group, archival research and scientific research, provide a model for future studies in conflict archaeology in Australia. The archival, archaeological and scientific research outcomes strongly support, although do not prove, the oral testimonies of the descendant group, that is, that an unknown number of people were at old Denison Downs Station adjacent to Sturt Creek, south-east Kimberley Region in 1922.

The combined evidence from the X-ray diffraction analyses and the anatomical and zooarchaeological reports support the oral testimonies of the descent group, that is, that a massacre of Aboriginal people took place at the 'women and children' site and the goat yard.

Both scatters of fragmented bone were formed entirely from burnt or bone and small quantities of charcoal and there was no archaeological evidence of teeth or cultural activities associated with Aboriginal people. The bone fragments are, however, degraded, small and fragile and although three bone fragments exhibited probable anthropomorphic characteristics, it was not possible to demonstrate beyond doubt that the bone fragments are from humans.

Importantly for future archaeological research addressing Australian sites of frontier conflict, this project identified archaeological signatures for the identification of probable massacre sites where the bodies of those killed were destroyed by an intense burning event. Such signatures will inevitably vary, but at two sites in a desert environment on the Sturt Creek they are: (i) scatters of highly fragmented bone < 20 mm in size and white to bluish white or brown to black in colour and absence of morphological characteristics and teeth; (ii) X-ray diffraction analysis of sixteen bone fragments demonstrated the crystallinity of the hydroxylapatite phase, an indication that the hydroxylapatite was well crystalline, this is typical of high temperature burning over a several hours, found to be over eighty hours in this study, and fueled by constant a constant supply of fuel; (iii) absence of any cultural material indicating a hearth, cooking, or other cultural activities; (iv)

presence of other evidence of burning at extremely high temperatures, for example, rocks and charcoal associated with the scatters of fragmented bone.

Acknowledgements

The senior Custodians, Evelyn Clancy, Speiler Sturt, Daisy Kungah, Shirley Yoomarie, Mabel Yoomarie, Stephen Yoomarie and other members of the Yoomarie family shared their knowledge, assisted with the archaeological survey and supported this project over several years. Emeritus Professor Jim Bowler, Wayne Bergman (past CEO, Kimberley Land Council), Justin Yoomarie, Dr Richard Smith and Kim Mahood all made valuable contributions to the project. We acknowledge the contribution made by the late Emeritus Professor Barrie Vernon-Roberts; he was the former Director of the Institute of Medical and Veterinary Science, Adelaide, and undertook the anatomical pathology investigation.

Funding for this project was awarded to the Kimberley Land Council, Broome, Western Australia in 2009 by the Australian Institute of Aboriginal and Torres Strait Studies, Canberra. Refer to AIATSIS Grant no. G2008-7363. Flinders University, Adelaide, provided additional support for incidental expenses.

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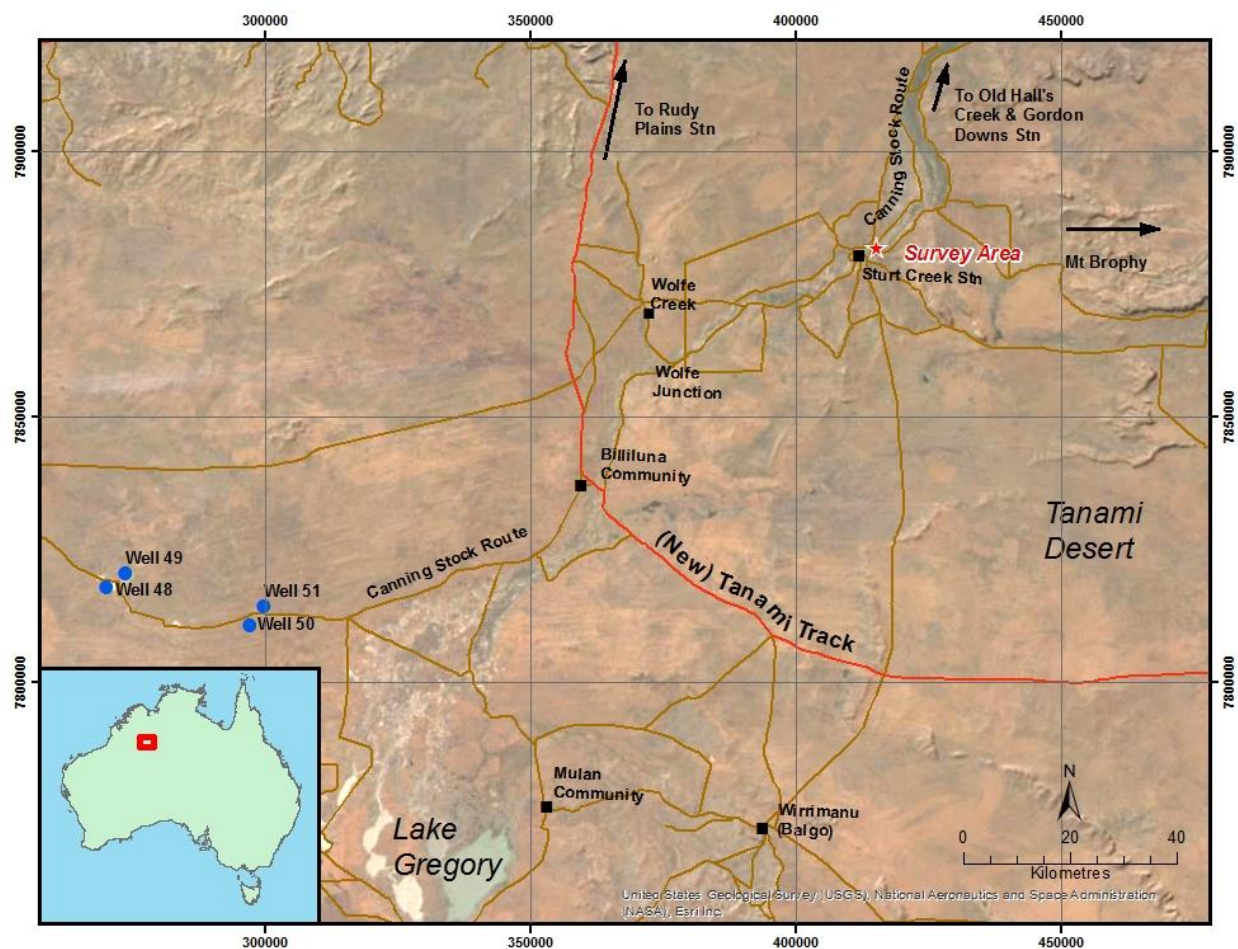


Figure 1. Map showing the location of Sturt Creek Station, the Canning Stock Route, the new Tanami Track, Wells 48, 49, 51 and 50 and Study Area on Sturt Creek, southeast Kimberley Region, Western Australia. (Source: Robert Keane, Spatial Systems Analyst, Flinders University)

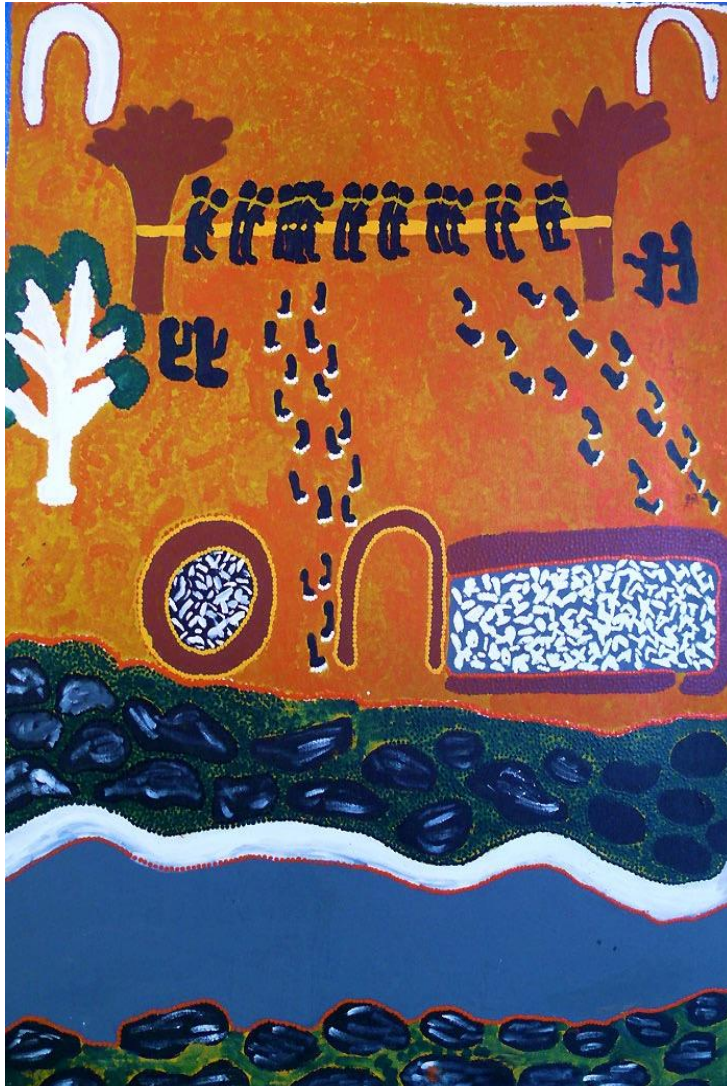


Figure 2. The Sturt Creek Massacre – undated painting. This painting illustrates the massacre event. The artists were Launa Yoomarri and Daisy Kungah painting under the direction of Clancy and Speiler Sturt (sons of Riwarri). The Aboriginal prisoners are chained between two trees. The four figures (two left and two right) hold guns. The footsteps end at the well and goat yard, and both contain fragmented bone. The white line and black stones on either side of the creek, Sturt Creek, represent the ‘milky’ coloured water of Sturt Creek and the black stone along the banks are what Daisy Kungah described as purrkui, the jupilkarn (cormorants) in the dreamtime. Permission to reproduce the painting was given by the artists at a meeting with the Custodians at Billiluna, August 2010. (Source: Kuningarra School, Billiluna Aboriginal Community, Western Australia)

many were now in the homes of people living in their community.



Figure 3. This photograph, showing one of ten scrapes made in the goat yard, illustrates the size of the white bone fragments. Small fragments of charcoal are also present.



Figure 4. Photograph showing burnt rock exposed in the compacted layer of burnt or bone fragments at the 'women and children' site.

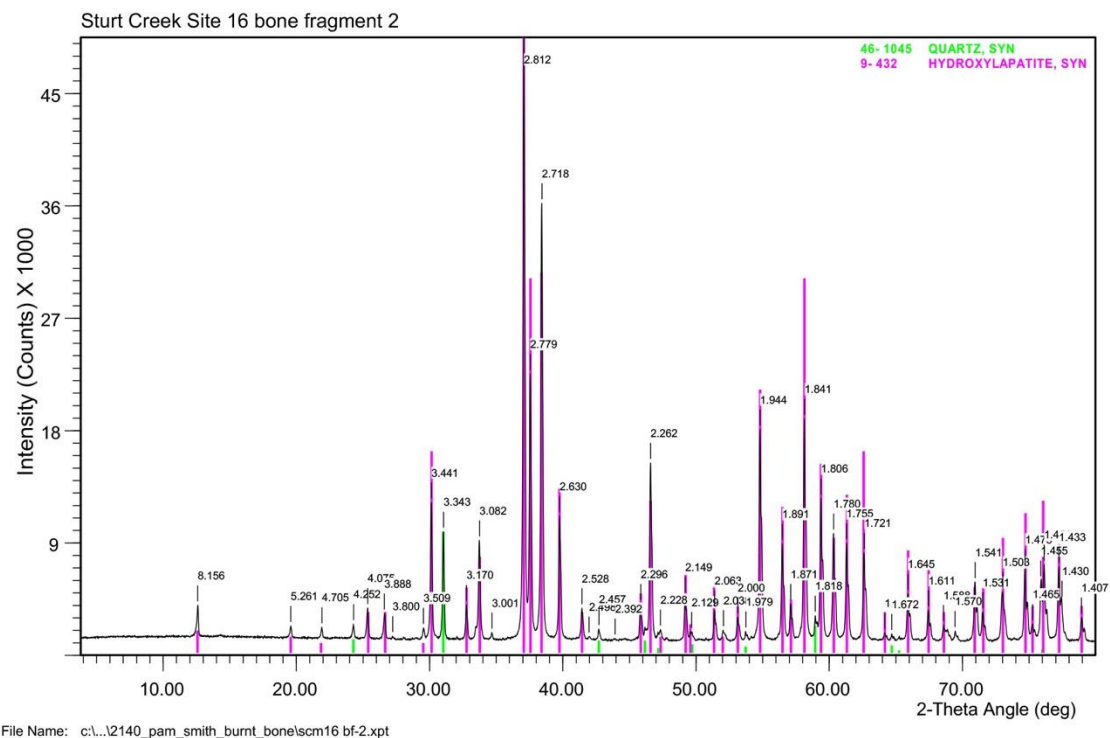


Figure 5. X-ray diffraction (XRD) pattern of bone fragment no.2 from Sturt Creek Site 16. The colour-coded stick pattern shows the expected positions and intensities of the phase listed at the top right of the pattern, namely quartz (green) and hydroxylapatite (purple).

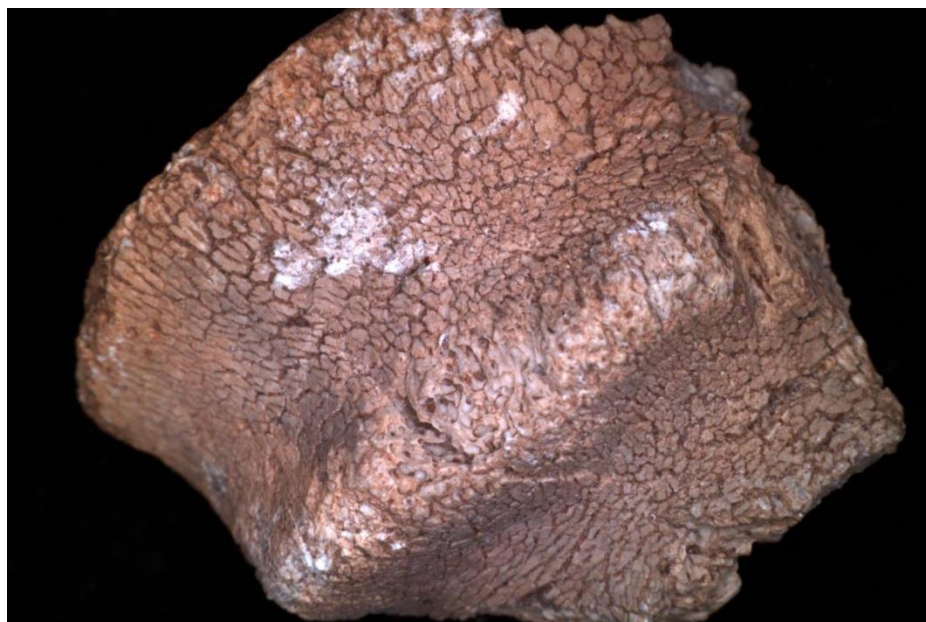


Figure 6. Sturt Creek Site Bone fragment no.2 (6.3 x Mag, FOV=24mm).

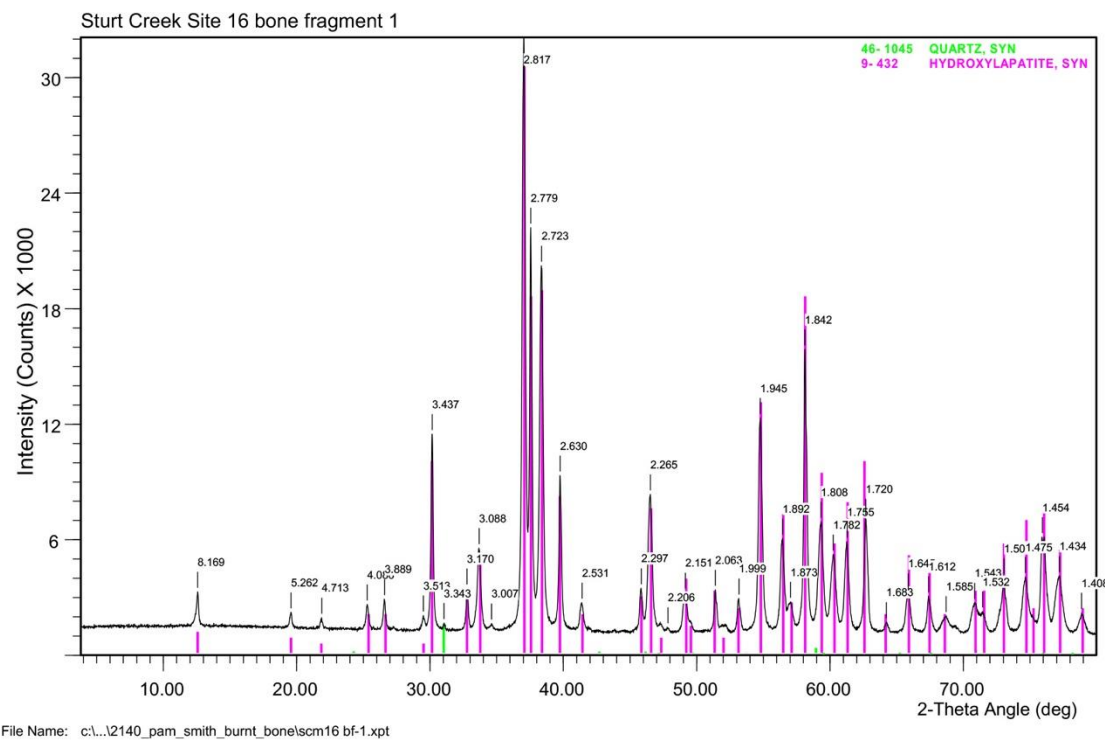


Figure 7. X-ray diffraction (XRD) pattern of bone fragment no.1 from Sturt Creek Site 16.



Figure 8. Sturt Creek Site 16 Bone fragment no.1 (6.3x Mag, FOV=24mm).

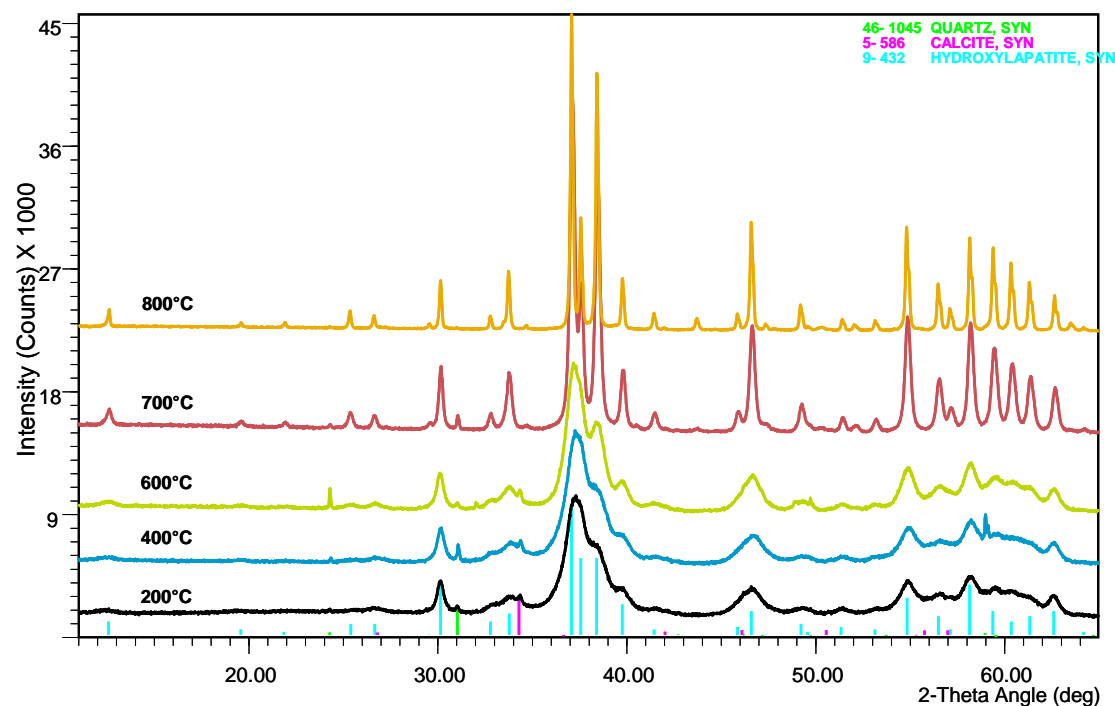


Figure 9. XRD patterns of successively heated bone comprising hydroxylapatite showing poorly crystalline hydroxylapatite (determined by the sharpness of the apatite XRD peaks) heated at 200°C and relatively well crystalline hydroxylapatite after heating at 700°C and 800°C (Co K-alpha radiation). Comparison between these XRD patterns of the bone fragments from Sturt Creek Site (see Figures 5 and 7) with laboratory heated bone (figure 10) indicates significant changes in degree of hydroxylapatite crystallinity, enabling temperature and duration of heating to be determined.

Crystallite size	>700nm
600°C	>140 hours
650°C	>60 hours
700°C	>60 hours
800°C	>1 hour

Table 1. Estimate of bone crystallite size of hydroxylapatite for bone fragment no.2 from Sturt Creek Site 16 and temperature of heating.

Crystallite size	~380nm
600°C	>120 hours
650°C	>20 hours
700°C	>10 hours
800°C	>1 hour

Table 2. Estimate of bone crystallite size of hydroxylapatite for bone fragment no.1 from Sturt Creek Site 16 and temperature of heating.